Independent Claim 1 and selected dependent claims have been amended to more clearly recite Applicants' invention and further distinguish it from the cited art. In amending the claims, the objections to Claims 14, 19-21 and 37 as set forth on pages 2 and 3 of the Office Action have been addressed. In addition, Claims 38-46 have been added to provide an additional scope of protection.

Claims 1, 23, 26 and 30 stand rejected under 35 U.S.C. §112, second paragraph, as allegedly being indefinite. Particular attention was paid to the grounds for this rejection as set forth on pages 3-5 of the Office Action in amending the claims as shown above. Accordingly, it is submitted that all the claims are in compliance with the particularity and distinctness requirements of the statute, and thus reconsideration and withdrawal of the rejection under 35 U.S.C. §112, second paragraph, is respectfully requested.

Applicants note with appreciation that Claims 8-30 are indicated as containing patentable subject matter. As explained in more detail below, Claim 1 has been amended and now includes features of Claims 7 and 8. Claim 1, therefore, is submitted to be allowable.

Claims 1, 2 and 31-36 stand rejected under 35 U.S.C. §102(e) as allegedly being anticipated by Takahashi '610. Claims 1, 3-7, 31, 32, 35 and 36 were rejected under 35 U.S.C. §102(b) as allegedly being anticipated by Matsumoto '028. Finally, Claims 1, 3-7, 31, 32, 35 and 36 stand rejected under 35 U.S.C. §102(b) as allegedly being anticipated by Williamson '310.

Claim 1 recites a projection optical system for projecting an image of an object onto an image plane, and comprises a first imaging optical system for forming an image of the object, and a second imaging optical system for re-imaging the image upon the image plane. The first imaging optical system includes a first mirror for reflecting and collecting abaxial light from

the object, and a refractive lens having a positive refractive power. In addition, a second mirror reflects light from the first mirror to the image plane side, whereby the abaxial light is caused to pass outside of an effective diameter of the first mirror. In addition, a lens group having a negative refractive power is disposed between the first and second mirrors and between the first mirror and the refractive lens.

As will be appreciated, the projection optical system in Claim 1 includes recitation of a lens group having a negative refractive power and disposed between the first mirror and the refractive lens having a positive refractive power (as in Claim 8). It is respectfully submitted, therefore, that independent Claim 1 is patentable over the cited art.

Takahashi relates to a projection optical system that includes a first optical system 10 and a second optical system 20. The first optical system includes two reflective mirrors, and the second optical system includes a convex mirror and a concave mirror.

Matsumoto relates to a reflection type projection optical system in which a first optical subsystem S1 forms a reduced image and a second optical subsystem S2 forms a further reduced object image. The first optical subsystem includes a concave first reflecting surface M1, a convex second reflecting surface M2, and a concave third reflective surface M3.

Williamson relates to an optical projection reduction system that includes a first image optical system for forming an image of the object, and a second imaging optical system for re-imaging the image upon the image plane.

Whether taken individually or even in combination, these citations fail to teach or suggest the projection optical system including the features set forth in Claim 1 as discussed

above. Accordingly, reconsideration and withdrawal of the rejections of the claims under 35 U.S.C. §102 is respectfully requested.

Newly submitted independent Claim 40 is also submitted to be patentable over the cited art.

Claim 40 relates to a projection optical system for projecting an image of an object onto an image plane, and includes a first imaging optical system for forming an image of the object, and a second imaging optical system for re-imaging the image upon the image plane. The first imaging optical system includes a first mirror for reflecting and collecting abaxial light from the object. A second mirror reflects light from the first mirror to the image plane side, whereby the abaxial light is caused to pass outside of an effective diameter of the first mirror, and a field optical system includes three lenses each having a positive refractive power. The abaxial light passed through the outside of the effective diameter of the first mirror is refracted by the three lenses toward a direction nearing an optical axis of the three lenses, with light emitted from the three lenses being directed to the second imaging optical system.

Accordingly, it is submitted that Applicants' invention as set forth in independent Claims 1 and 40 is patentable over the cited art. In addition, dependent Claims 2, 9-39 and 41-46 set forth additional features of Applicants' invention. Independent consideration of the dependent claims is respectfully requested.

In view of the foregoing, reconsideration and allowance of this application is deemed to be in order and such action is respectfully requested.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,

Scott D. Malpede

Attorney for Applicants
Scott D. Malpede
Registration No. 32,533

FITZPATRICK, CELLA, HARPER & SCINTO
30 Rockefeller Plaza
New York, New York 10112-3801
Facsimile: (212) 218-2200

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

The paragraph starting at page 1, line 13 and ending at line 19 has been amended as follows:

The density of an integrated circuit increases more and more, and the specification and performance required for a projection (exposure) optical system become much [strict] stricter. Generally, in order to obtain a higher resolving power, the exposure wavelength is shortened and/or the numerical aperture (NA) of a projection optical system is enlarged.

The paragraph starting at page 1, line 20 and ending at page 3, line 4 has been amended as follows:

However, as the exposure wavelength reaches a region of 193 nm (Arf excimer laser light) or 157 nm (F_2 excimer laser light), usable lens materials are limited to quartz and fluorite. This is mainly because of decreases of the light transmission factor. For example, in a projection optical system such as disclosed in Japanese Laid-Open Patent Application, Laid-Open No. 79345/[1935]1998, wherein it comprises all dioptric lenses of a large number and wherein all lenses have a large glass material thickness, the exposure amount on a wafer becomes low and it causes a decrease of the throughput. Also, due to thermal absorption by the lenses, there occur problems (thermal aberration) such as changes of aberration or shift of the focal point position. [Where] When the exposure wavelength is 193 nm, quartz and fluorite can be used as a projection optical system. However, because the difference in dispersion between them is not large, correction of chromatic aberration is difficult to accomplish. In order to correct the

chromatic aberration of a projection optical system completely, it is necessary to use a few achromatic lenses having a small curvature radius at its achromatic surface. This leads to an increase of the total glass material thickness of the optical system, which then raises the above-described problems of thermal aberration and transmission factor. Further, currently, it is very difficult to produce a projection optical system by use of fluorite, having a sufficient property to assure its design performance. It is further difficult to produce one having a large diameter. This makes it very difficult to accomplish color correction, and results in an increase of the cost. As for the exposure wavelength of 157 nm, only fluorite is the usable lens material. The chromatic aberration [can not] <u>cannot</u> be corrected only with a single lens material. [Any way] <u>Anyway</u>, it is very difficult to provide a projection optical system only by use of dioptric systems.

The paragraph starting at page 3, line 20 and ending at page 4, line 5 has been amended as follows:

[Where] <u>When</u> a projection optical system which includes a catoptric system to meet the shortening of the exposure wavelength and the enlargement of NA (numerical aperture) is produced, the structure should of course be one that enables correction of chromatic aberration. In addition, idealistically, the structure should be simple and [enough] <u>sufficient</u> to enable that an imaging region of sufficient size is defined upon an image plane, that the number of optical elements such as mirrors or lenses is small, that the mirror incidence angle and reflection angle are not large, and that a sufficient image-side working distance is assured.

The paragraph starting at page 4, line 6 and ending at page 5, line 5 has been amended as follows:

If an imaging region width of sufficient size is attainable on the image plane, in the case of scan type projection exposure apparatus, it is advantageous [in] with respect to the throughput, such that the exposure variation can be suppressed. If the number of optical elements is small, the process load in the production of optical elements such as mirrors and lenses can be reduced. Also, since the total glass material thickness can be made smaller, the loss of light quantity can be reduced. Further, the increase of the footprint of the apparatus can be suppressed, and the loss of light quantity due to the film can also be decreased. Particularly, this is very advantageous because, [where] when the exposure wavelength is 157 nm (F_2 excimer laser light), the loss of light quantity at the mirror reflection film [can not] cannot be disregarded. [Where] When the mirror incidence angle and the reflection angle are not large, the influence of a change in light quantity due to the angular characteristic of the reflection film can be suppressed. If a sufficient image-side working distance can be maintained, it is advantageous [in] with respect to structuring an autofocusing system or a wafer stage conveyance system in the apparatus. If the structure is simple, complicatedness of a mechanical barrel, for example, can be avoided, and it provides an advantage to the manufacture.

The paragraph starting at page 5, line 6 and ending at line 7 has been amended as follows:

Here, the conventional examples are considered [in] with respect to the above-described points.

The paragraph starting at page 5, line 8 and ending at line 23 has been amended as follows:

In the projection optical system shown in U.S. Patent No. 5,650,877, a Mangin mirror and a refracting member are disposed in an optical system to print an image of a reticle on a wafer. This optical system has inconveniences that, in every picture angel used, there occurs light interception (void) at the central portion of a pupil and that the exposure region [can not] cannot be made large. If the exposure region is to be enlarged, it disadvantageously causes widening of the light interception at the central portion of the pupil. Further, the refractive surface of the Mangin mirror defines a beam splitting surface such that the light quantity decreases to a half each time the light passes this surface. The light quantity will be decreased to about 10% upon the image plane (wafer surface).

The paragraph starting at page 5, line 24 and ending at page 6, line 9 has been amended as follows:

In the projection optical systems shown in Japanese Laid-Open Patent Applications, Laid-Open Nos. 211332/1997 and 90602/1998, the basic structure comprises a reflection system only. However, [in] with respect to aberration (Petzval sum) and mirror disposition, it is difficult to keep a sufficient imaging region width on the image plane. Also,

since, in this structure, a concave mirror adjacent to the image plane and having a large power mainly has an imaging function, enlargement of NA is difficult to accomplish. Since a convex mirror is placed just before the concave mirror, a sufficient image-side working distance [can not] cannot be maintained.

The paragraph starting at page 6, line 24 and ending at page 7, line 20 has been amended as follows:

In the projection optical systems shown in Japanese Laid-Open Patent Applications, Laid-Open Nos. 163319/1988, 188298/1993 and 230287/1994, the structure is complicated due to deflection and bend of the optical path. Since most of the power of optical groups for imaging an intermediate image, as a final image, is sustained by concave mirror, it is structurally difficult to enlarge the NA. The magnification of the lens system which is disposed between the concave mirror and the image plane is at a reduction ratio and also it has a positive sign. Because of it, a sufficient image-side working distance [can not] cannot be kept. Further, in order that the object plane and the image plane are placed opposed, it is necessary to use two flat mirrors only for the sake of deflection of the optical path, without any contribution to aberration correction. As the exposure wavelength is shorted to 157 nm, this is undesirable also [in] with respect to the loss of light quantity. Further, it is structurally difficult to hold the imaging region width because of the necessity of light path division. Since the optical system has to be large, there is a disadvantage [in] with respect to the footprint.

The paragraph starting at page 7, line 21 and ending at page 8, line 10 has been amended as follows:

In the projection optical systems shown in Japanese Laid-Open Patent Applications, Laid-Open Nos. 66510/1990 and 282527/1991, the optical path is divided by a beam splitter, and this makes the barrel structure complicated. It needs a beam splitter of large diameter and, if this is of a prism type, the loss of light quantity is large because of its thickness. For a larger NA, a larger diameter is necessary, and thus the loss of light quantity becomes larger. If the beam splitter is of a flat plate type, there will occur astigmatism and [comma] <u>coma</u> even in regard to axial light rays. Further, there may occur aberrations due to a change in characteristic at the light dividing surface or production of asymmetric aberration resulting from thermal absorption. It is therefore difficult to manufacture the beam splitter very accurately.

The paragraph starting at page 11, line 17 and ending at line 19 has been amended as follows:

(13) A projection optical system according any one of Items (9) to (12), wherein said field optical system is [all] constituted by lenses.

The paragraph starting at page 11, line 20 and ending at page 12, line 3 has been amended as follows:

(14) A projection optical system according to any one of Items (9) to (12), wherein said field optical system comprises a first field mirror and a second field mirror group

including a second field mirror, wherein abaxial light passed through the outside of the effective diameter of said first mirror group is reflected by said first field mirror and said second field mirror, in this order, and after that, the light passes a region adjacent to the optical axis of said first [filed] field mirror and enters said second imaging optical system.

The paragraph starting at page 12, line 4 and ending at line 7 has been amended as follows:

(15) A projection optical system according to Item (14) wherein said first [filed] field mirror comprises a concave mirror and wherein said second field mirror comprises a convex mirror.

The paragraph starting at page 12, line 8 and ending at line 11 has been amended as follows:

(16) A projection optical system according to Item (14) wherein said first [filed] field mirror comprises a concave mirror and wherein said second field mirror comprises a concave mirror.

The paragraph starting at page 15, line 7 and ending at line 9 has been amended as follows:

(32) A projection optical system according to any one of Items (1) to (31), wherein said projection optical system has a magnification of a reduction ratio.

The paragraph starting at page 17, line 13 and ending at line 16 has been amended as follows:

Figure 12 is a schematic view of a light path in a case, in Example of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 17, line 17 and ending at line 20 has been amended as follows:

Figure 13 is a schematic view of a light path in a case, in Example 6 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 17, line 21 and ending at line 24 has been amended as follows:

Figure 14 is a schematic view of a light path in a case, in Example 7 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 17, line 25 and ending at page 18, line 1 has been amended as follows:

Figure 15 is a schematic view of a light path in a case, in Example 8 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 18, line 2 and ending at line 5 has been amended as follows:

Figure 16 is a schematic view of a light path in a case, in Example 9 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 18, line 6 and ending at line 9 has been amended as follows:

Figure 17 is a schematic view of a light path in a case, in Example 10 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 18, line 10 and ending at line 13 has been amended as follows:

Figure 18 is a schematic view of a light path in a case, in Example 11 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 18, line 14 and ending at line 17 has been amended as follows:

Figure 19 is a schematic view of a light path in a case, in Example 12 of the present invention, wherein a field optical system is [all] constituted by lens systems.

The paragraph starting at page 24, line 26 and ending at page 25, line 1 has been amended as follows:

The refractive lens group R may be disposed in the group L2, including two mirrors, that is, the first and <u>second</u> mirrors M1 and M2.

The paragraph starting at page 25, line 7 and ending at line 24 has been amended as follows:

[Where] <u>When</u> the refractive lens group R is disposed between the refractive lens group L1 and the first mirror M1, the structure is such as called a reciprocal optical system. Namely, into this refractive lens group R, the light refracted by the refractive lens group L1 enters and, additionally, the light reflected by the second mirror M2 passes therethrough. [Where] <u>When</u> this refractive lens group R is used, the refracting power thereof should desirably be negative. If the refracting power of the refractive lens group R is negative, the Petzval sum which the first mirror M1 bears is shared. Also, it contributes to correction of chromatic aberration in the whole system. Thus, if the refractive lens group R is provided, it should desirably have a negative refracting power. Further, simultaneously, it contributes to correction of [comma] <u>coma</u> aberration and spherical aberration of the whole system.

The paragraph starting at page 25, line 25 and ending at page 26, line 9 has been amended as follows:

As described hereinbefore, mainly for correction of axial chromatic aberration or the like, the refractive lens group R should preferably be disposed about the first mirror M1. However, it may be disposed adjacent to the second mirror R. Namely, it may be disposed at a position for transmitting the reflection light from the first mirror M1 and the reflection light from the second mirror. Further, the refractive lens group R may be disposed at any place within the range of the group L2, including two mirrors. Also, lens elements of any number may be used.

The paragraph starting at page 26, line 10 and ending at line 13 has been amended as follows:

The projection optical system in this embodiment, particularly [where] when it is provided by a [twice] double-imaging optical system, has a positive magnification.

The paragraph starting at page 26, line 21 and ending at page 28, line 4 has been amended as follows:

In accordance with another embodiment of the present invention, a catadioptric projection optical system such as shown in Figure 3, for example, is provided (Second Embodiment). In this embodiment, the region of the object plane from which the light reaches the image plane and which is attributable to the imaging is a semi-arcuate zone (ring-like [filed] field) outside the optical axis, and there is no void at the central portion of the light upon the pupil plane. The projection optical system comprises, in an order along the optical path from the object side, a first imaging system Gr1 having a function for forming an intermediate image of

the object, a field optical system Grf for projecting a pupil of the first imaging system Gr1 onto a pupil of a second imaging system Gr2, and the second imaging system Gr2 is disposed just before the image plane and operates to form a final image. The first imaging system Gr1 includes two mirror groups, i.e., a first mirror group Gm1 including a first mirror M1 and having a positive refracting power, and a second mirror group GM2 including a second mirror M2. The second mirror group GM2 is disposed physically at the object side of the first mirror group GM1, and the first mirror M1 is a concave mirror having its concave surface facing to the object side. The light from the object side is reflected by the first and second mirrors M1 and M2, in this order, inside the first imaging system Gr1. After this, the light goes through the outside of the effective diameter of the first mirror group GM1 toward the image side, and it passes through the field optical system Grf and the second imaging system Gr2. Thus, the whole system of the projection optical system is defined along a straight optical axis 103. The object plane and the image plane are opposed to each other, at the opposite ends of the optical axis 103. The magnification of the projection optical system is a reduction ratio.

The paragraph starting at page 28, line 5 and ending at line 15 has been amended as follows:

Figure 3 is a schematic view of a basic structure of the second embodiment, and Figures 12 - 45 show Examples 5 - 21, respectively, to which the second embodiment is applied, to be described later. In all examples, the first imaging system Gr1 has two mirrors, and the second imaging system Gr2 comprises refractive lens systems only. Figures 12 - 19 [shows]

<u>show</u> cases wherein the field optical system Grf is [all] provided by lens systems, and Figures 20 - 28 show cases wherein the field optical system Grf has two mirrors.

The paragraph starting at page 28, line 16 and ending at line 17 has been amended as follows:

Generally, [where] <u>when</u> a mirror is used, the optical system functions as follows.

The paragraph starting at page 29, line 5 and ending at line 8 has been amended as follows:

Because of this, the optical system has to be complicated to place the object and image planes opposed to each other. For example, there [occur] <u>occurs a</u> void in the pupil, ring field, <u>and</u> bend of optical path.

The paragraph starting at page 29, line 9 and ending at page 30, line 19 has been amended as follows:

In this embodiment, to accomplish the above-described purposes, the functions of a mirror such as described above are effectively reflected to the optical system. As shown in Figure 3, the structure is simple and the projection optical system is disposed along a straight optical axis 103, although it uses a first imaging system, a field optical system, a second imaging system and a mirror, as shown in Figure 3. This provides significant advantages. Since there is

no necessity of bending the optical path, the barrel structure can be made simple like that of a conventional refractive lens system. As regards the self-weight deformation of an optical element, since the gravity direction and the optical axis direction are registered with each other, there does not occur asymmetrical deformation. Thus, an asymmetrical aberration does not occur easily. Current [equipments] equipment for the manufacture, such as peripheral [equipments] equipment for assembling and adjustment as well as instruments for measurement, for example, can be used. This is very advantageous [in] with respect to the cost. Further, since the footprint of the apparatus is substantially the same as that of a conventional refractive lens system, the area to be occupied is unchanged. This feature is accomplished by the arrangement that, while an optical system concept (ring field system) in which only paraxial light contributes to the imaging, is set, the function (c) described above is used twice in the first imaging system Gr1, and [twice] double reflections are accomplished with the use of two mirrors, and that the light from the object side is directed through the outside of the effective diameter of the first mirror group GM1 to the image side. The light thereafter passes through the field optical system Grf and the second imaging system Gr2, and it reaches the image plane. Thus, an optical system having a single optical axis is accomplished.

The paragraph starting at page 30, line 20 and ending at page 31, line 12 has been amended as follows:

The second imaging system Gr2 is [all] provided by refractive lens system, and it has a positive refracting power. With this structure, enlargement of the NA can be met and,

additionally, the image side working distance can be assured easily. If the second imaging system Gr2 has a concave mirror, as described with reference to the conventional examples, it becomes difficult to enlarge the NA and to keep the image side working distance. The field optical system Grf may be [all] provided by refractive lens systems, as shown at (A) in Figure 3. Alternatively, it may comprise two mirrors, such as shown at (B) in Figure 3. As will be described later in relation to examples, depending on the power arrangement, the positive lens FL1 may be omitted. In the case of (B) in Figure 3, the field optical system Grf includes a first field mirror FM1, comprising a concave mirror, and a second field mirror FM2, comprising a convex mirror. The second field mirror may be provided by a concave mirror.

The paragraph starting at page 31, line 13 and ending at line 23 has been amended as follows:

As regards the color correction, the achromatic state of the first imaging system Gr1 may be made "over achromatism" on the basis of the function (a) described above, when the first mirror group GM1 is constituted by a lens LN1 of negative refracting power as well as the first mirror M1 which is a concave mirror. Thus, even though a single glass material is used for the lens, correction of chromatic aberration can be attained. This is very advantageous particularly for use of an Arf excimer laser or <u>an</u> F_2 excimer laser.

The paragraph starting at page 33, line 19 and ending at page 34, line 13 has been amended as follows:

As regards the incidence angle and reflection angle of light on the mirror, because this embodiment concerns a ring field system, because this embodiment concerns a ring field system, the incidence angle and the reflection angle of the light on the mirror can be made smaller than that in an optical system of a Cassegrain type or Schwarzschild type. Further, in the first imaging system Gr1, the first mirror M1 is disposed adjacent to a point optically conjugate with a pupil, and the light reflected by the second mirror M2 passes about the outside of the effective diameter of the first mirror group GM1. Since the light is not reflected at a high position away from the optical axis of the mirror, the incidence angle and the reflection angle of the light on the first and second mirrors M1 and M2 do not become extraordinarily large. In a case where the field optical system Grf has a structure as shown at (B) in Figure 3, the spacing between the first and second field mirrors FM1 and FM2 is kept large as much as possible. Also, the width of light is narrow. Therefore, the incidence angle and the reflection angle do not become extraordinarily large.

The paragraph starting at page 34, line 14 and ending at line 26 has been amended as follows:

As regards the width of the imaging region on the image plane, the mirror should be disposed so as to keep the effective light as much as possible. [Where] When the field optical system Grf comprises only a refractive lens system ([Figured] Figure 3, (A)) or it includes a mirror (Figure 3, (B)), in the first imaging system Gr1, the object height may be made high within the tolerable range of aberration correction. Thus, this is not an obstacle. In the field

optical system Grf having a field mirror (Figure 3, (B)), since the width of light is narrow, it is easy to avoid an eclipse of the effective light flux. Therefore, a sufficient imaging region width can be attained.

The paragraph starting at page 34, line 27 and ending at page 35, line 27 has been amended as follows:

In the first imaging system Gr1, a positive lens group G1 may be disposed just after the object plane. This is effective for the correction of distortion aberration, for example, and to maintain its object-side telecentricity satisfactorily. Therefore, in order to reduce any warp of the object plane (reticle) or image plane (wafer) or to decrease a change in magnification due to defocus, it is desirable to provide an optical system being telecentric both in the object side and the image side, by using the positive lens group G1 and the second imaging system Gr2. In the present invention, as shown in Figure 3, the second mirror M2 should have a half disk-like shape, for separation of light. The positive lens group G1 may have either a half disk-like shape, or it may have a disk-like shape for easiness of lens manufacture and lens holding. Further, the second mirror M2 may be formed at the surface portion below the optical axis. For the same reason, the lens LP1 having a half disk-like shape, may have a disk-like shape. [In] On that occasion, the light passes the lens LP1 three times. Similarly, the second mirror M2 may be formed at the lower surface portion of the lens LP1. Also, the first mirror M1 may be formed as a back-surface mirror of the lens LN1. The mirrors used in the present invention may be back-surface mirrors, [in] with respect to the aberration correction.

The paragraph starting at page 36, line 17 and ending at line 19 \has been amended as follows:

[Where] When the magnification of the second imaging system Gr2 is BG2, the following relation should be satisfied:

The paragraph starting at page 36, line 21 and ending at line 23 has been amended as follows:

[Where] When the magnification of the first imaging system Gr1 is BG1, the following relation should be satisfied:

The paragraph starting at page 37, line 11 and ending at line 15 has been amended as follows:

[Where] When the paraxial distance between the first and second mirrors is LM2, and the paraxial distance from the object plane to the intermediate image by the first imaging system OIL, the distance LM1 described above satisfies the following relation:

The paragraph starting at page 37, line 20 and ending at line 23 has been amended as follows:

[Where] When the distance from the object plane to the image plane with respect to the projection optical system is L, the distance LM1 described above satisfies the following relation:

The paragraph starting at page 41, line 4 and ending at page 42, line 5 has been amended as follows:

Condition (5) concerns the positional relation of the intermediate image by the first imaging system Gr1 and the first mirror M1. Under the condition, the reflection light from the second mirror M2 efficiently passes toward the image side without interference with the first mirror group GM1. As shown in Figure 3, it is preferable that an intermediate image is formed substantially outside the first mirror M1. Thus, if this range is exceeded, the width of light outside the first mirror M1 becomes large, and the diameter of the field optical system Grf becomes large. This causes an increase of aberration. Particularly, if the lower limit is exceeded, the magnification of the first imaging system Gr1 becomes too small, and there may occur an inconvenience of interference of the reflection light from the second mirror M2 with the first mirror group GM1. Further, the powers of the first and second mirrors M1 and M2 become too large, and the amount of aberration production undesirably increases. If the upper limit is exceeded, to the contrary, the magnification of the first imaging system Gr1 becomes too large. As a result, an excessive space is produced outside the first mirror M1, or the magnification has to be reduced by means of the second imaging system Gr2. Thus, the power balance of the optical system as a whole is undesirably [be] destroyed. The upper limit of the condition (5) may preferably be equal to 3.0.

The paragraph starting at page 44, line 15 and ending at page 45, line 2 has been amended as follows:

Important features of an embodiment such as shown at (B) in Figure 3 reside in that, in the first imaging system Gr1, the above-described function (c) [are] <u>is</u> used twice such that the reflection is performed twice by using two mirrors of the first and second mirrors M1 and M2, and that the light from the object is directed through the outside of the effective diameter of the first mirror group GM1 to the image plane side. Also, even in the field optical system Grf, the above-described function (c) is used twice, and the reflection is made twice by using two mirrors of first and second field mirrors FM1 and FM2, so that the light is directed to the image plane side through the optical axis central portion of the first field mirror FM1.

The paragraph starting at page 45, line 5 and ending at line 7 has been amended as follows:

[Where] <u>When</u> the magnification of the first imaging system Gr1 is BG1, the following relation should be satisfied:

The paragraph starting at page 46, line 20 and ending at page 47, line 11 has been amended as follows:

In the second embodiment of the present invention as described above, the optical system comprises a first imaging system, a field optical system and a second imaging system. Two mirrors of the first imaging system are used to perform reflection twice, to direct light to the image plane side. By this, the structure becomes very simple wherein the optical axis extends <u>along</u> a single straight line. Further, when predetermined conditions such as positional

relations of the mirrors, and magnification sharing of each imaging system and each mirror group, are satisfied, a sufficient imaging region width is attainable. Thus, a catadioptric projection optical system which is small in size and light in weight, which has optical elements of a reduced number, which has incidence angles and reflection angles on the mirrors not being very large, and which has a sufficient image side working distance, is accomplished.

The paragraph starting at page 47, line 12 and ending at line 15 has been amended as follows:

[Specific] A specific example of the present invention will now be described. Examples 1 - 4 are those based on the first embodiment described above, and examples 5 - 21 are those based on the second embodiment.

The paragraph starting at page 48, line 13 and ending at line 17 has been amended as follows:

Figure 8 shows longitudinal and transverse aberrations of this example, and structural specifications of a numerical example are shown in Table 1. The aberrations in the drawing concern the base wavelength 157 nm ±2 pm.

The paragraph starting at page 49, line 1 and ending at line 8 has been amended as follows:

The refractive lens group R (reciprocal optical system) comprises an aspherical negative lens of meniscus shape, having a concave surface facing to the object side. With this negative lens, mainly the curvature of field and axial chromatic aberration are corrected. Also, with the aspherical surface, mainly the spherical aberration and [comma] coma aberration, for example, are corrected.

The paragraph starting at page 49, line 9 and ending at line 26 has been amended as follows:

The first mirror M1 comprises an aspherical surface concave mirror having a concave surface facing to the object side. It has a positive refracting power and functions to produce a curvature of field in the positive direction to cancel the negative curvature of field of the second imaging optical system which comprises a refractive lens. The second mirror M2 comprises a concave mirror having a concave surface facing to the image side, and it serves to direct the abaxial light on the first object 101 to the outside of the effective diameter of the first mirror M1. An intermediate image is formed adjacent to the outside of the effective diameter of the first mirror M1. In this example, the first imaging optical system is an enlarging system, and separation between the reflection light from the first mirror M1 and the reflection light from the second mirror M2 is accomplished easily.

The paragraph starting at page 50, line 3 and ending at line 27 has been amended as follows:

The second imaging optical system G2 comprises, in an order from the object side, an aspherical positive lens of meniscus shape having a concave surface facing to the object side, an aperture stop, an aspherical positive lens of approximately flat-convex shape having a convex surface facing to the image side, an aspherical positive lens having a convex surface facing to the object side, an aspherical lens having a concave surface facing to the image side, an aspherical lens having a convex surface facing to the image side, and an aspherical positive lens having a convex surface facing to the object side. The second imaging optical system G2 provides a reduction system for imaging the light from the field lens group F onto the second object surface 102. Because the light is incident on the aperture stop with a certain angle, the effective diameter of the refractive lens about the aperture stop can be suppressed to be small. With this arrangement, various aberrations such as axial chromatic aberration and spherical aberration can be reduced and, additionally, they can be cancelled with various aberrations produced in the first imaging optical system. Thus, satisfactory aberration correction is accomplished in the whole system.

The paragraph starting at page 52, line 5 and ending at line 9 has been amended as follows:

Figure 9 shows longitudinal and transverse aberrations of this example, and structural specifications of a numerical example [is] are shown in Table 2. The aberrations in the drawing concern the base wavelength and a wavelength ±2 pm.

The paragraph starting at page 54, line 3 and ending at line 7 has been amended as follows:

Figure 10 shows longitudinal and transverse aberrations of this example, and structural specifications of <u>a</u> numerical example [is] <u>are</u> shown in Table 3. The aberrations in the drawing concern the base wavelength 157 mn ±2 pm.

The paragraph starting at page 54, line 16 and ending at page 55, line 8 has been amended as follows:

The first mirror M1 comprises an aspherical surface concave mirror having a concave surface facing to the object side. It has a positive refracting power and functions to produce a curvature of field in the positive direction to cancel the negative curvature of field of the second imaging optical system which comprises a refractive lens. The second mirror M2 comprises an aspherical surface concave mirror having a concave surface facing to the image side, and it serves to direct the abaxial light on the first object 101 to the outside of the effective diameter of the first mirror M1. An intermediate image is formed adjacent <u>to</u> the outside of the effective diameter of the first mirror M1. In this example, a field lens group F is disposed adjacent to the intermediate image. This field lens group F comprises, in an order from the object side, an aspherical positive lens of meniscus shape having a convex surface facing to the image side, and an aspherical positive lens of biconvex shape.

The paragraph starting at page 55, line 9 and ending at line page 56, line 6 has been amended as follows:

The second imaging optical system G2 comprises, in an order from the object side, an aspherical positive lens of meniscus shape having a convex surface facing to the object side, an aperture stop, an aspherical positive lens of approximately flat-convex shape having a convex surface facing to the image side, an aspherical positive lens having a convex surface facing to the object side, aspherical lens having a concave surface facing to the image side, an aspherical lens having a convex surface facing the to the image side, and an aspherical positive lens having a convex surface facing to the object side. The second imaging optical system for imaging the light from the field lens group F onto the second object surface 102. Because the light is incident on the aperture stop with a certain angle, the effective diameter of the refractive lens about the aperture stop can be suppressed <u>to be</u> small. With this arrangement, various aberrations such as axial chromatic aberration and spherical aberration can be reduced and, additionally, they can be cancelled with various aberrations produced in the first imaging optical system. Thus, satisfactory aberration correction is accomplished in the whole system.

The paragraph starting at page 56, line 8 and ending at line 11. A marked-up copy of this paragraph, showing the changes made thereto is attached.

Figure 7 shows a specific lens structure of Example 4. The projection magnification was 1:5, and the design base wavelength was 157 nm (wavelength of <u>an</u> F_2 excimer laser). The glass material was fluorite.

The paragraph starting at page 56, line 12 and ending at line 20 has been amended as follows:

In this embodiment, the image side numerical aperture was NA = 0.60, and the object-to-image distance (from the first object plane to the second object plane) was L = about 1411 mm. In the range of the image height of about 9 - 15 mm, the aberration was corrected. An abaxial exposure region of an arcuate shape, having at least a size of about 20.8 mm in the lengthwise direction and 5 mm in the width was assured.

The paragraph starting at page 56, line 21 and ending at line 24 has been amended as follows:

Figure 11 shows longitudinal and transverse aberrations of this example, and structural specifications of a numerical example are shown in Table 4.

The paragraph starting at page 57, line 10 and ending at line 20 has been amended as follows:

The first mirror M1 comprises an aspherical surface concave mirror having a concave surface facing to the object side. The second mirror M2 comprises an aspherical surface concave mirror having a concave surface facing to the image side, and it serves to direct the abaxial light on the first object 101 to the outside of the effective diameter of the first mirror M1. An intermediate image is formed adjacent to the outside of the effective diameter of the first mirror M1. In this example, the first imaging optical system G1 constitutes a reduction system.

The paragraph starting at page 58, line 4 and ending at line 9 has been amended as follows:

In the four examples described above, except Example 2, the first mirror M1 is [all] defined by an aspherical surface. Further, except Examples 1 and 2, all the refractive lenses are aspherical lenses. However, a spherical lens may be used in combination.

The paragraph starting at page 58, line 15 and ending at line 24 has been amended as follows:

In Examples 1 - 4 described above, the exposure region has an arcuate shape. However, as long as <u>it is</u> inside the aberration-corrected range, any other shape such as a rectangular shape may be used. Further, while the group L2 having two mirrors is shown as including the refractive lens group R, the refractive lens group R and the mirrors may be integrated (Mangin mirror structure). Alternatively, the refractive lens group R and the second mirror M2 may be integrated into a Mangin mirror structure.

The paragraph starting at page 58, line 25 and ending at page 59, line 1 has been amended as follows:

In the examples described above, while there is [an] aspherical surface data in which the conical constant k is taken as zero, the design may be made while using the conical constant as a variable.

The paragraph starting at page 59, line 2 and ending at line 11 has been amended as follows:

The exposure light source used an F_2 laser of a wavelength 157 nm. However, a KrF excimer laser (wavelength 248 nm) or <u>an</u> ArF excimer laser (wavelength 193 nm), for example, may be used. Particularly, the invention is effective [where] <u>when</u> the wavelength is shortened and usable optical materials are limited, and the number of optical elements should be reduced. Thus, the present invention is effective [to] <u>for</u> an optical system to be used with a wavelength not longer than 250 nm.

The paragraph starting at page 59, line 12 and ending at line 18 has been amended as follows:

In these examples, fluorite was used as the glass material for the wavelength 157 nm from the F_2 excimer laser. However, any other glass material such as [fluorine-doped] <u>fluorine-doped</u> quartz, for example, may be used. [Where] <u>When</u> a KrF or <u>an</u> ArF light source is used, fluorite and quartz may be used in combination, or only one of them may be used.

The paragraph starting at page 60, line 18 and ending at page 61, line 1 has been amended as follows:

Structural specifications of numerical examples are shown in Table 5. In this example, an image side working distance of 30 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 224.7 mm. While the largest diameter of

the optical system as a whole is 227 mm at the field optical system, the largest diameter of the second imaging system is as small as 125 mm, regardless [of] that the NA is 0.6. Figure 29 shows aberrations, and from this, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 62, line 8 and ending at line 18 has been amended as follows:

Structural specifications of numerical examples are shown in Table 6. In this example, an image side working distance of 31 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 232.1 mm. While the largest diameter of the optical system as a whole is 196 mm at the field optical system, the largest diameter of the second imaging system is as small as 143 mm, regardless [of] that the NA is 0.6. Figure 30 shows aberrations, and from this, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 63, line 23 and ending at page 64, line 6 has been amended as follows:

Structural specifications of numerical examples are shown in Table 7. In this example, an image side working distance of 31 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 333.8 mm. While the largest diameter of the optical system as a whole is 250 mm at the field optical system, the largest diameter of the second imaging system is as small as 143 mm, regardless of [that] the NA is 0.6. Figure 31 shows aberrations, and from this, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 65, line 13 and ending at line 23 has been amended as follows:

Structural specifications of numerical examples are shown in Table 8. In this example, an image side working distance of 36. 1 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 337.6 mm. While the largest diameter of the optical system as a whole is 245 mm at the field optical system, the largest diameter of the second imaging system is as small as 142 mm, regardless [of] that the NA is 0.6. Figure 32 shows aberrations, and from this, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 67, line 14 and ending at line 24 has been amended as follows:

Structural specifications of numerical examples are shown in Table 9. In this example, an image side working distance of 30.3 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 400.5 mm. While the largest diameter of the optical system as a whole is 213 mm at the field optical system, the largest diameter of the second imaging system is as small as 157 mm, regardless [of] that the NA is 0.6. Figure 33 shows aberrations, and from this, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 69, line 9 and ending at line 20 has been amended as follows:

Structural specifications of numerical examples are shown in Table 10. In this example, an image side working distance of 30.0 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 375.9 mm. While the largest diameter of the optical system as a whole is 266 mm at the field optical system, the largest diameter of the second imaging system is as small as 105 mm, regardless [of] that the NA is 0.6. Figure 34 shows aberrations with respect to the base wavelength 157 nm and a wavelength range of 2 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 71, line 2 and ending at line 13 has been amended as follows:

Structural specifications of numerical examples are shown in Table 11. In this example, an image side working distance of 30.0 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 371.9 mm. While the largest diameter of the optical system as a whole is 328 mm at the field optical system, the largest diameter of the second imaging system is as small as 141 mm, regardless [of] that the NA is 0.6. Figure 35 shows aberrations with respect to the base wavelength 157 nm and a wavelength range of 2 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 72, line 9 and ending at line 16 has been amended as follows:

Denoted at r13 - r20 are components of a field optical system Grf, and it comprises three positive lenses, including a positive lens FL1 of doughnut shape, [having a] <u>being</u> hollow at its center, and being disposed outside the first mirror M1, and one negative lens. Denoted at r21 - r31 are components of a second imaging system Gr2, and it comprises a stop r25, four positive lenses and one negative lens.

The paragraph starting at page 72, line 17 and ending at page 73, line 8 has been amended as follows:

In this example, since the pupil conjugate point of the first imaging system Gr1 is placed closer to the object side, a value close to the lower limit of condition (4) is taken. Further, like Example 10, due to the structure of the first mirror group GM1 as described, the effect of correcting chromatic aberration is enhanced. Also, the positive lens FL1 of the field optical system Grf is made into a doughnut shape, and the first mirror group GM1 of the first imaging system Gr1 is disposed at the central portion of the doughnut shape. With this structure, the light rays can be refracted at a position closer to the object side and, therefore, the powers of the field optical system Grf and the second imaging system Gr2 can be made smaller. This is very advantageous [in] <u>with</u> respect to the aberration correction. Further, the second mirror group GM2 is provided by the positive lens LP1 and the second mirror M2, to thereby control the Petzval sum.

The paragraph starting at page 73, line 9 and ending at line 20 has been amended as follows:

Structural specifications of numerical examples are shown in Table 12. In this example, an image side working distance of 30.0 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 377.0 mm. While the largest diameter of the optical system as a whole is 328 mm at the field optical system, the largest diameter of the second imaging system is as small as 144 mm, regardless [of] that the NA is 0.6. Figure 36 shows aberrations with respect to the base wavelength 157 nm and a wavelength range of 2 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 74, line 20 and ending at page 75, line 3 has been amended as follows:

Structural specifications of numerical examples are shown in Table 22. In this example, an image side working distance of 30.0 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 192.2 mm. While the largest diameter of the optical system as a whole is 388 mm at the field optical system, the largest diameter of the second imaging system is as small as 167 mm, regardless [of] that the NA is 0.6. Figure 37 shows aberrations. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 76, line 11 and ending at line 21 has been amended as follows:

Structural specifications of numerical examples are shown in Table 14. In this example, an image side working distance of 30 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 156.4 mm. While the largest diameter of the optical system as a whole is 444 mm at the field optical system, the largest diameter of the second imaging system is <u>as</u> small as 144 mm, regardless [of] that the NA is 0.6. Figure 38 shows aberrations. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 76, line 23 and ending at page 77, line 5 has been amended as follows:

Figure 22 is an optical path view of Example 15 of the present invention. The design base wavelength was 157 nm of F_2 excimer laser light, the NA was 0.6, and the projection magnification β was 1:4. The lens conjugate distance L was 1190 mm. The optical system had an exposure region (imaging region) upon an image plane, of an arcuate shape, at the image height from [9.56m] <u>9.56 mm</u> to 13.65 mm. The optical system was provided by use of four mirrors and eight lenses (two lenses added to Example 13).

The paragraph starting at page 78, line 8 and ending at line 19 has been amended as follows:

Structural specifications of numerical examples are shown in Table 15. In this example, an image side working distance of 36 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 203.7 mm. While the largest diameter of the optical system as a whole is 512 mm at the field optical system, the largest diameter of the second imaging system is as small as 146 mm, regardless [of] that the NA is 0.6. Figure 39 shows aberrations with respect to the base wavelength 157 nm and a wavelength range of 4 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 80, line 3 and ending at line 13 has been amended as follows:

Structural specifications of numerical examples are shown in Table 16. In this example, an image side working distance of 36 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 292.8 mm. While the largest diameter of the optical system as a whole is 294 mm at the field optical system, the largest diameter of the second imaging system is as small as 184 mm, regardless [of] that the NA is 0.6. Figure 40 shows aberrations. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 80, line 15 and ending at line 23 has been amended as follows:

Figure 24 is an optical path view of Example 17 of the present invention. The design base wavelength was 157 nm of F_2 excimer laser light, the NA was 0.6, and the projection

magnification β was 1:4. The lens conjugate distance L. was 1188 mm. The optical system had an exposure region (imaging region) upon an image plane, of an arcuate shape, at the image height from [9.56m] 9.56 mm to 13.65 mm. The optical system was provided by use of four mirrors and nine lenses.

The paragraph starting at page 82, line 6 and ending at line 18 has been amended as follows:

Structural specifications of numerical examples are shown in Table 17. In this example, an image side working distance of 36 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 303.3 mm. While the largest diameter of the optical system as a whole is 323 mm at the field optical system, the largest diameter of the second imaging system is as small as 125 mm, regardless [of] that the NA is 0.6. Figure 41 shows aberrations, with respect to the base wavelength 157 nm and a wavelength [rang] range of 2 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 83, line 24 and ending at page 84, line 9 has been amended as follows:

Structural specifications of numerical examples are shown in Table 18. In this example, an image side working distance of 37 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 286.8 mm. While the largest diameter of the optical system as a whole is 442 mm at the field optical system, the largest diameter of the

second imaging system is as small as 165 mm, regardless [of] that the NA is 0.6. Figure 42 shows aberrations, with respect to the base wavelength 157 nm and a wavelength [rang] range of 4 pm. From the drawing, it is seen that the aberrations are corrected satisfactorily.

The paragraph starting at page 85, line 7 and ending at line 18 has been amended as follows:

In this example, with the use of the first mirror group GM1 as provided by the negative lens LN1 and the first mirror M1, color correction is accomplished. Further, with the use of the second field mirror group GFM 2 which is provided by the second field mirror FM2 (convex) and the positive lens LF, the Petzval sum is also controlled. Since the magnification of the first imaging system Gr1 is at the most reduction rate, a value close to the upper limit of condition (9) is taken. Since the spacing between the second and first field mirrors FM2 and FM1 is relatively small, a value close to the lower limit of condition (14) is taken.

The paragraph starting at page 85, line 19 and ending at page 86, line 4 has been amended as follows:

Structural specifications of numerical examples are shown in Table 19. In this example, an image side working distance of 33.7 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 264.4 mm. Further, the largest diameter of the whole optical system is very short, as small as 293 mm, and also the largest diameter of the second imaging system is as small as 130 mm, regardless [of] that the NA is 0.6.

Figure 43 shows aberrations, with respect to the base wavelength 157 nm and a wavelength [rang] range of 2 pm. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 87, line 3 and ending at line 20 has been amended as follows:

In this example, since the magnification of the first imaging system Gr1 is strongly enlarged, a value close to the lower limit of condition (9) is taken. This is because the magnification of the first mirror group GM1 is positive, and because a value close to the upper limit of condition (13) is taken. As a result, a value close to the upper limit of condition (11) is taken, and the position of the intermediate image produced by the first imaging system Gr1 is far remote from the first mirror M1. Further, since the pupil conjugate point of the first imaging system Gr1 is at the image plane side with respect to the first mirror M1, a value close to the upper limit of condition (10) is taken. Additionally, with the use of the second field mirror group GFM2 which is provided by the second field mirror FM2 (convex) and the negative lens LF, the Petzval sum is also controlled.

The paragraph starting at page 87, line 21 and ending at page 88, line 4 has been amended as follows:

Structural specifications of numerical examples are shown in Table 20. In this example, an image side working distance of 36 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 315.5 mm. While the largest diameter of

the optical system as a whole is 355 mm at the field optical system, the largest diameter of the second imaging system is as small as 177 mm, regardless [of] that the NA is 0.6. Figure 44 shows aberrations. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 88, line 6 and ending at line 15 has been amended as follows:

Figure 28 is an optical path view of Example 21 of the present invention. The design base wavelength was 157 nm of F_2 excimer laser light, the NA was 0.6, and the projection magnification β was 1:10. The lens conjugate distance L was 1190 mm. The optical system had an exposure region (imaging region) upon an image plane, of an arcuate shape, at the image height from 9.56 mm to 13.65 mm. The optical system was provided by the use of four mirrors and nine lenses, like Example 16.

The paragraph starting at page 89, line 3 and ending at line 13 has been amended as follows:

In this example, the magnification of the second imaging system Gr2 has a value close to the lower limit of condition (1). Also, the distance between the second and first mirrors M2 and M1 is short, and a value close to the lower limit of condition (6) is taken. Further, with the use of the first mirror group GM1 being provided by the negative lens LN1 and the first mirror M1 as well as the second field mirror group GFM2 which is provided by the second field mirror FM2 (convex) and the negative lens LF, the Petzval sum is also controlled.

The paragraph starting at page 89, line 14 and ending at line 24 has been amended as follows:

Structural specifications of numerical examples are shown in Table 21. In this example, an image side working distance of 36 mm is assured, and the total glass material length along the optical path is extraordinarily shortened to 301.7 mm. While the largest diameter of the optical system as a whole is 310 mm at the field optical system, the largest diameter of the second imaging system is as small as 180 mm, regardless [of] that the NA is 0.6. Figure 45 shows aberrations. From the drawing, it is seen that aberrations are corrected satisfactorily.

The paragraph starting at page 89, line 25 and ending at page 90, line 12 has been amended as follows:

In Examples 5 - 21 described above, aspherical surface are used and, among the [used] aspherical surfaces used, there are lens surfaces having a conical constant k set to zero. However, design may be made while taking the conical constant k as a variable. Further, in these examples, the wavelength of an F_2 excimer laser was used as a design wavelength, and fluorite (n = 1.5600) was used as the glass material for it. However, any other glass material such as [fluorine doped] fluorine-doped quartz, for example, may be used. [Where] When a KrF or an ArF light source is used, fluorite and quartz may be used in combination. Alternatively, only one of them may be used and, [in] on that occasion, since the dispersion of glass material is smaller, the correction of chromatic aberration becomes easier.

The paragraph starting at page 90, line 13 and ending at line 23 has been amended as follows:

A projection optical system according to [theses] these examples may be used as a projection optical system in a scan type projection exposure apparatus for projecting a pattern (device pattern such as a circuit pattern) of a reticle or a mask onto a substrate or a wafer in accordance with a step-and-scan procedure. A wafer is exposed to a device pattern by use of such an exposure apparatus, and then, the exposure wafer is developed. Through subsequent processes such as etching, devices (semiconductor chips) are produced.

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE ABSTRACT

The Abstract of the Disclosure section starting at page 123, line 2 and ending at line 17 has been amended as follows:

[Disclosed is a] A projection optical system [for projecting] projects an image of an object onto an image plane, [which] and includes a first imaging optical system for forming an image of the object, and a second imaging optical system for re-imaging the image upon the image plane, wherein the first and second imaging optical systems are disposed in an order from the object side and are disposed along a common straight optical axis[, wherein the]. The first imaging optical system includes a first mirror for reflecting and collecting abaxial light from the object, wherein one of the first and second imaging optical systems includes a second mirror for reflecting light from the first mirror to the image plane side, and wherein, with the second mirror, the abaxial light is caused to pass an outside of an effective diameter of the first mirror.

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

1. (Amended) A projection optical system for projecting an image of an object onto an image plane, comprising:

a first imaging optical system for forming an image of the object, said first imaging optical system including a first mirror for reflecting and collecting abaxial light from the object, and a refractive lens having a positive refractive power;

a second imaging optical system for re-imaging the image upon the image plane;

[wherein said first and second imaging optical systems are disposed in an order from the object side and are disposed along a common straight optical axis, wherein said first imaging optical system includes a first mirror for reflecting and collecting abaxial light from the object, wherein one of said first and second imaging optical systems includes a second mirror for reflecting light from said first mirror to the image plane side, and wherein, with said second mirror, the abaxial light is caused to pass an outside of an effective diameter of said first mirror]

a second mirror for reflecting light from said first mirror to the image plane side, whereby the abaxial light is caused to pass outside of an effective diameter of said first mirror; and

a lens group having a negative refractive power and being disposed between said first and second mirrors and between said first mirror and said refractive lens.

3. Cancelled.

4. Cancelled.

5. Cancelled.

6. Cancelled.

7. Cancelled.

8. Cancelled.

9. (Amended) A projection optical system according to Claim 1, further comprising a field optical system disposed between said first and second imaging optical systems, for projecting a pupil of said first imaging optical system onto said second imaging optical system, wherein said first imaging optical system comprises a first mirror group of positive refracting power, including at least said first mirror, and a second mirror group including said second mirror, wherein light from said first mirror group as reflected by said second mirror group is caused to pass [an] outside of an effective diameter of said first mirror group.

10. (Amended) A projection optical system according to Claim 9, wherein said second imaging optical system is constituted by lenses only and [it] has a positive refracting power.

14. (Amended) A projection optical system according to Claim 9, [wherein said] further comprising a field optical system [comprises] including a first field mirror group having a first field mirror and a second field mirror group including a second field mirror, wherein abaxial light passed through the outside of the effective diameter of said first mirror group is reflected by said first field mirror and said second field mirror, in this order, and after that, the light passes a region adjacent the optical axis of said first [filed] field mirror and enters said second imaging optical system.

15. (Amended) A projection optical system according to Claim 14, wherein said first [filed] field mirror comprises a concave mirror and wherein said second field mirror comprises a convex mirror.

16. (Amended) A projection optical system according to Claim 14, wherein said first [filed] field mirror comprises a concave mirror and wherein said second field mirror comprises a concave mirror.

19. (Amended) A projection optical system according to Claim 9, wherein the distance LM1 satisfies a relation $0.5 < OIL/(LM1 + 2xLM2) < 20$, where LM2 is a paraxial distance between said first and second mirrors, and OIL is a paraxial distance along the optical path, from the object to the image defined by said first imaging optical system, wherein LM1 is a

paraxial distance between the object and said first mirror, and LM2 is a paraxial distance between said first and second mirrors.

20. (Amended) A projection optical system according to Claim 9, wherein the distances LM1 and LM2 satisfy a relation 0.2 < LM2/LM1 < 0.95, wherein LM1 is a paraxial distance between the object and said first mirror, and LM2 is a paraxial distance between said first and second mirrors.

21. (Amended) A projection optical system according to Claim 9, wherein the distance LM1 satisfies a relation 0.15 < LM1/L < 0.55, where L is a distance from an object plane to an image plane in said projection optical system, wherein LM1 is a paraxial distance between the object and said first mirror, and LM2 is a paraxial distance between said first and second mirrors.

22. (Amended) A projection optical system according to Claim 9, wherein said first mirror group has a magnification BGM1, which satisfies a relation -2.0 < 1/BGM1 < 0.4.

23. (Amended) A projection optical system according to Claim 9, wherein said first imaging optical system has a lens group [of] having a positive refracting power[,] and disposed closest to the object side.

26. (Amended) A projection optical system according to Claim 9, wherein the abaxial light from the object passes through a lens of said second mirror group before it is incident on said first mirror group.

28. (Amended) A projection optical system according to Claim 14, wherein a relation $0.45 < LFM1/LFM2 < 0.8$ is satisfied, where LFM1 is a distance between said second field mirror and said first field mirror, and LFM 2 is a distance between said second field mirror and the image plane.

30. (Amended) A projection optical system according to Claim 14, wherein a positive lens, included by said field optical system, is disposed between said first mirror of said first imaging optical system and said second field mirror of said field optical system, wherein light reflected by said second mirror of said first imaging optical system passes through said positive lens and then is reflected by said first field mirror.

35. (Amended) A projection exposure apparatus for projecting a pattern of a mask onto a substrate through a projection optical system as recited in [any one of Claims 1 - 34] Claim 1.

37. (Amended) A device manufacturing method, comprising the steps of:

printing a device pattern on a wafer by exposure, using a projection exposure apparatus as recited in Claim 35 [or 36]; and

developing the exposed wafer.